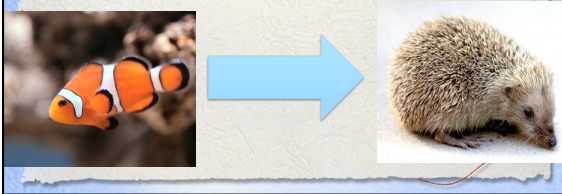


What does it take to move from Water to Land?

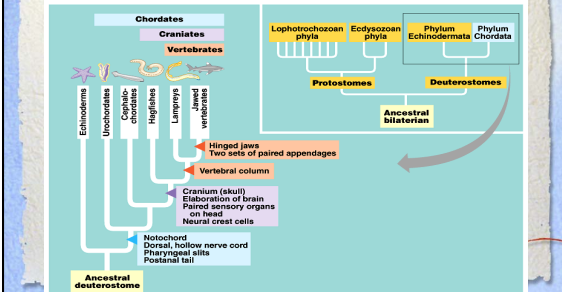
– Write out your hypothesis on a piece of butcher paper



Vertebrates

- Vertebrates include mammals, birds, lizards, snakes, turtles, amphibians, and the various classes of fishes.
- They share several unique features including a backbone, a series of vertebrae.
- The vertebrates belong to one of the two major phyla in the Deuterostomia, the **chordates**.

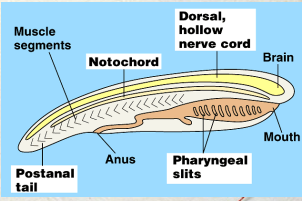
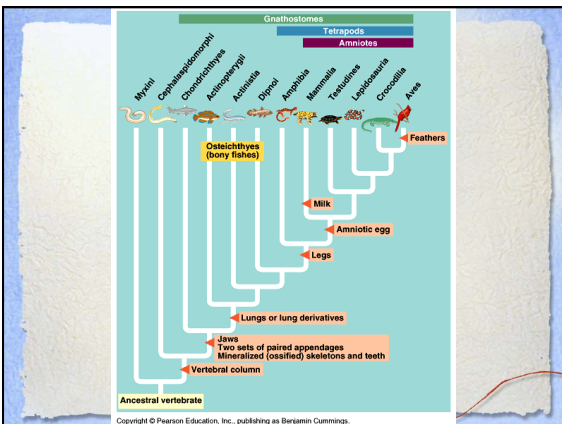
- The phylum Chordata includes three subphyla, the vertebrates and two phyla of invertebrates, the urochordates and the cephalochordates.



Reminder:

Four anatomical features characterize the phylum Chordata

- Although chordates vary widely in appearance, all share the presence of four anatomical structures at some point in their lifetime.
- These chordate characteristics are a notochord; a dorsal, hollow nerve cord; pharyngeal slits; and a muscular, postanal tail.

Evolutionary Progression

- A comparison of gnathostomes (jawed) and agnathans (jawless) shows that:
 1. The brain and cranium evolved first in the vertebrate lineage.
 2. This was followed by the vertebral column.
 3. The jaws, ossified skeleton, and paired appendages evolved later.

Major evolutionary breakthroughs:

1. Jaws
 - Jaws, with the help of teeth, enable the animal to **grip food** items firmly and slice them up.
 - Opens up new food options
2. Paired fins were
 - Paired fins, along with the tail, enable fishes to **maneuver** accurately while swimming.
- With these adaptations, many fish species were **active predators**, allowing for the diversification of both lifestyles and nutrient sources.

Hypothesis for the evolution of vertebrate jaws

The diagram illustrates the hypothesis for the evolution of vertebrate jaws. It shows three stages of a fish's head and mouth region. In the first stage, there are gill slits and a cranium. In the second stage, skeletal rods are shown forming between the gill slits, and a mouth is beginning to form. In the third stage, the skeletal rods have fused to form a jaw, and the mouth is fully developed.

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5. Fishes were prevalent about 360 to 400 million years ago- the "Age of Fishes"
6. Two groups are alive today:
 - a. Class **Chondrichthyes**: Sharks and rays have cartilaginous skeletons
 - b. **Osteichthyes**: Extant classes of bony fishes

Class **Chondrichthyes**: Sharks and rays have **cartilaginous skeletons**

- Relatively flexible endoskeletons of cartilage rather than bone.
 - In most species, parts of the skeleton are strengthened by mineralized granules, and the teeth are bony.

This is the most dangerous animal in the world, responsible for millions of deaths every year. By his side we can see a white shark swimming peacefully

There are about 750 extant species, almost all in the subclass of sharks and rays, with a few dozen species in a second subclass the chimaeras or ratfishes.
All have well-developed jaws and paired fins.

The Structure of Chondrichthyes

- The cartilaginous skeleton of these fishes is a derived characteristic, not a primitive one.
 - The ancestors of Chondrichthyes had bony skeletons.
 - The cartilaginous skeleton evolved secondarily.
- During the development of most vertebrates, the skeleton is first cartilaginous and then becomes ossified as hard calcium phosphate matrix replaces the rubbery matrix of cartilage.

Question

- What does it mean that "The cartilaginous skeleton of these fishes is a derived characteristic, not a primitive one?"

A Sharks Senses

- Acute senses are adaptations that go along with the active, carnivorous lifestyle of sharks.
 - Sharks have sharp vision but cannot distinguish colors.
 - Their acute olfactory sense (smelling) occurs in a pair of nostrils.
 - Sharks can detect electrical fields, including those generated by the muscle contractions of nearby prey, through patches of specialized skin pores.
 - The **lateral line system**, a row of microscopic organs sensitive to pressure changes, can detect low frequency vibrations.
 - In sharks, the whole body transmits sound to the hearing organs of the inner ear.


Reproduction

- Shark eggs are fertilized internally.
 - Males transfer sperm via claspers on their pelvic fins to the reproductive tract of the female.
 - **Oviparous** sharks encase their eggs in protective cases and lay them outside the mother's body.
 - These hatch months later as juveniles.
 - **Ovoviviparous** sharks retain fertilized eggs in the oviduct.
 - The embryo completes development in the uterus, nourished by the egg yolk.
 - A few sharks are **viviparous**, providing nutrients through a placenta to the developing offspring.

<http://dsc.discovery.com/tv-shows/shark-week/videos/shark-reproduction-video>

Rays

- Rays are closely related to sharks, but they have adopted a very different lifestyle.
 - Most rays are flattened bottom dwellers that crush mollusks and crustaceans in their jaws.
 - The enlarged pectoral fins of rays are used like wings to propel the animal through the water.
 - The tail of many rays is whiplike and may bear venomous barbs for defense against threats.




Osteichthyes: The extant classes of bony fishes are the ray-finned fishes, the lobe-finned fishes, and the lungfishes


- Bony fishes are the most numerous group of vertebrates, both in individuals and in species (about 30,000 species).
 - They range in size from 1 cm to more than 6 m.
 - They are abundant in the seas and in nearly every freshwater habitat.
- Traditionally, all bony fishes were combined into a single class, **Osteichthyes**, but most systematists now recognize *three* extant classes: the ray-finned fishes, the lobe-finned fishes, and the lungfishes.

Structure

- Nearly all bony fishes have an ossified endoskeleton with a hard matrix of calcium phosphate.
- The skin is often covered with thin, flattened bony scales.
- Like sharks, fishes can detect water disturbances through the **lateral line system**, part of which is visible as a row of tiny pits along either side of the body.



- Bony fishes breathe by drawing water over four or five pairs of gills located in chambers covered by a protective flap, the **operculum**.
 - Water is drawn into the mouth, through the pharynx, and out between the gills by movements of the operculum and muscles surrounding the gill chambers.

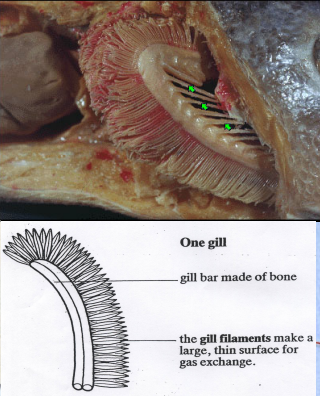


Operculum

Respiration:

Gills Structure

- The **gills** are made of numerous thin **filaments** supported by a **bony arch**.




The diagram shows a cross-section of a gill. It consists of a central **gill bar made of bone** from which numerous **gill filaments** extend. A note states: "the gill filaments make a large, thin surface for gas exchange."

Adaptations of the gills for efficient gas exchange

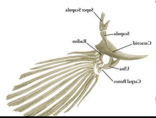
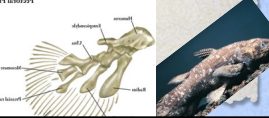
- Large surface area : volume
 - allows more diffusion of gases
- Permeable membranes
 - allows gases to diffuse through tissues
- Thin (flattened cells)
 - short diffusion distance
- Good vascular (blood) supply –
 - maintains concentration gradients

Reproduction

- The reproductive modes of fishes vary extensively.
 - Most species are **oviparous**, in which external fertilization occurs after the female sheds large numbers of small eggs & males synchronously release clouds of sperm (milt). - *Spray and Hope Method*
 - Membranous Eggs: Need to be in water or they will dry out.
 - However, internal fertilization occurs in many fish groups and some are even viviparous (live bearing).




Fish Types

<h4>Actinopterygii</h4> <h4>Ray-finned fishes:</h4> <ul style="list-style-type: none"> • Fins are supported by long flexible rays • The fins may be modified for maneuvering, defense, and other functions. <ul style="list-style-type: none"> – This class includes bass, trout, perch, tuna and herring. 	<h4>Sarcopterygii</h4> <h4>Lobe-finned fishes:</h4> <ul style="list-style-type: none"> • Muscular fins supported by extensions of the bony skeleton. <ul style="list-style-type: none"> – Many lobe-fins were large, bottom dwellers that may have used their paired, muscular fins to "walk" along the bottom. 
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Tictallic

- Notes:



Class Dipnoi

- Three genera of lungfishes (**class Dipnoi**) live today in the Southern Hemisphere.
 - They can gulp air into lungs connected to the pharynx of the digestive tract to provide oxygen for metabolism.
 - Lungfishes also have gills
 - They generally inhabit stagnant ponds and swamps.
 - When ponds shrink during the dry season, some lungfishes can burrow into the mud and aestivate (hibernate).

